

Pilot PM_{2.5} Forecasting Projects for 21 *USA Today* Cities

Presented by

Timothy S. Dye
Craig B. Anderson

David E. B. Strohm
Clinton P. MacDonald

Sonoma Technology, Inc.

Petaluma, CA

(707) 665-9900

www.sonomatech.com

tim@sonomatech.com

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Objective and Outline

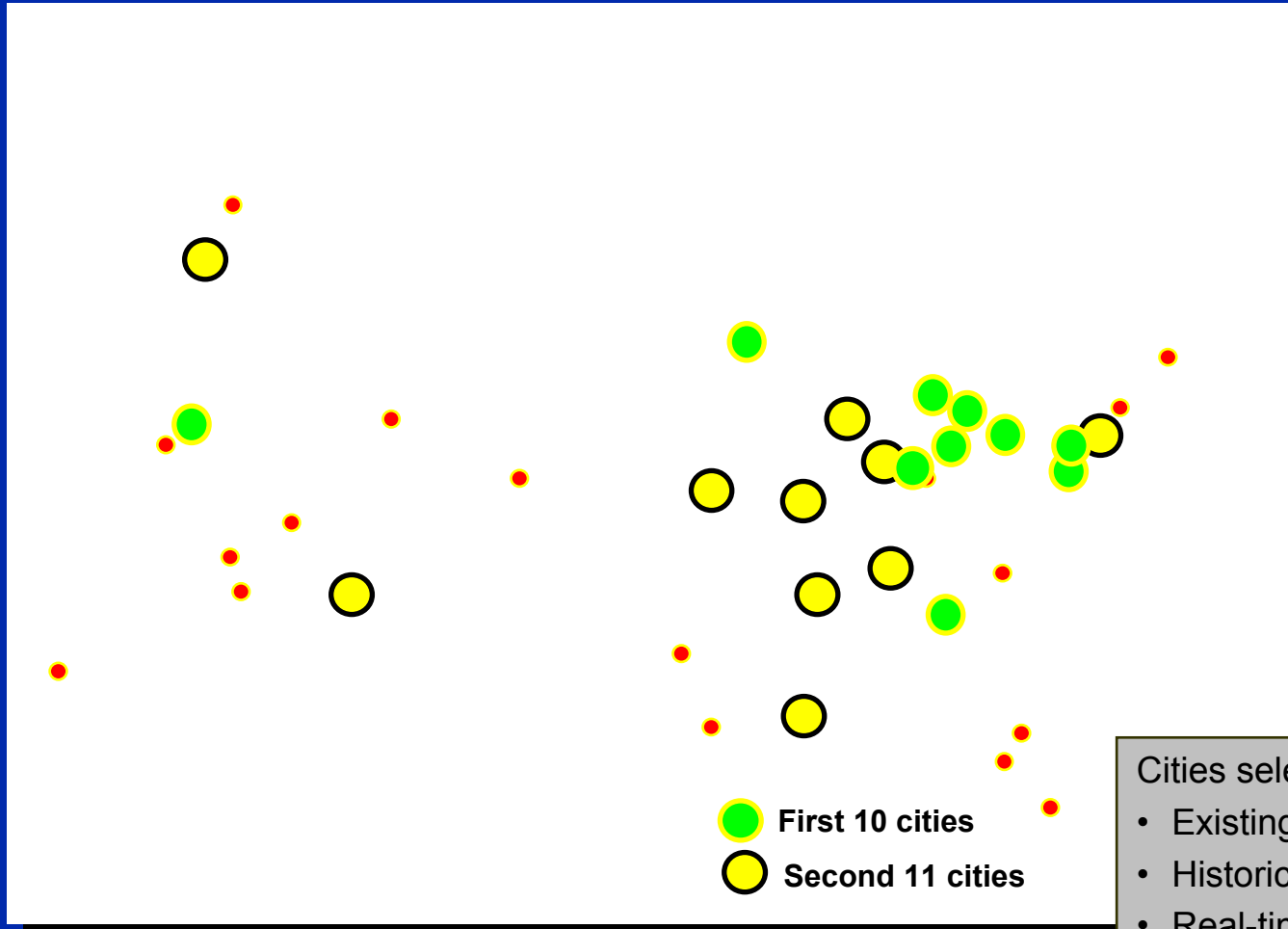
- Objectives:
 - Develop PM_{2.5} forecasting methods/tools and operationally forecast PM_{2.5} for 21 cities
 - Transfer knowledge and forecasting tools to each city
- Outline:
 - Background
 - Approach and schedule
 - Conceptual model development
 - Forecasting tool development
 - Operational forecasting and results
 - Forecasting software
 - Next steps

Background (1 of 2)

- Several driving issues
 - Health effects
 - PM_{2.5} year-round pollutant
 - Dominant wintertime pollutant
- Media's (*USA Today*) desire for year-round air quality forecasts
- Challenges
 - PM is different than ozone
 - Primary and secondary pollutant
 - Seasonal changes in PM
 - Regional differences in PM
 - Local hot spots
 - Very limited historical data
 - Uncertainties in continuous real-time data
 - PM chemistry is complex

Background (2 of 2)

USA Today Cities



First Priority
Atlanta
Baltimore
Cincinnati
Cleveland
Columbus
Detroit
Minneapolis
Pittsburgh
Sacramento
Washington D.C.

Second Priority
Chicago
Indianapolis
Kansas City
Las Vegas
Memphis
Nashville
New Orleans
Philadelphia
Phoenix
Portland
St. Louis

Cities selection based on

- Existing program
- Historical data
- Real-time data
- Severity of problem

Approach and Schedule

General approach

- Select cities (Oct)
- Acquire historical data (focus on FRM, 24-hr average measurements) (Oct-Jan)
- Quality control data (Oct-Jan)
- Develop conceptual model understand weather and air quality in each city (Oct-Jan and Feb-Mar)
- Develop forecasting tools (Dec-Feb)
- Conduct operational forecasting (Jan-April)
- Document tools and lessons learned (April-May)
- Evaluate forecasts (May-June)
- Transfer tools and knowledge to staff in each city (June-July)

Conceptual Model Development

- Components of a Conceptual Model
 - Climatology Analysis: Examine past air quality conditions to help characterize PM_{2.5} episodes and provide guidelines for forecasters
 - Weather Characterization: Examine the large-scale weather patterns that influence PM_{2.5} concentrations
 - Case Studies: Conduct detailed analysis of specific episodes to understand local processes that affect PM_{2.5}
- Forecasting tools are based on this conceptual understanding.
 - Phenomenological forecast tables
 - Statistical tool development

Conceptual Model – Climatology (1 of 2)

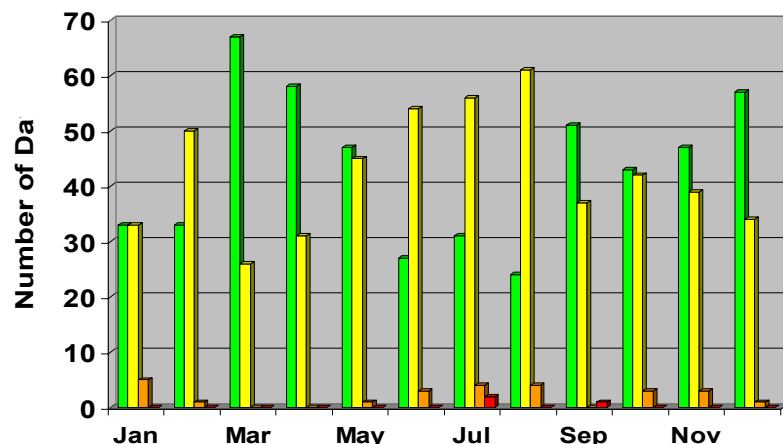
Developed a climatology for each city:

Examined the frequency and characteristics of PM_{2.5} episodes

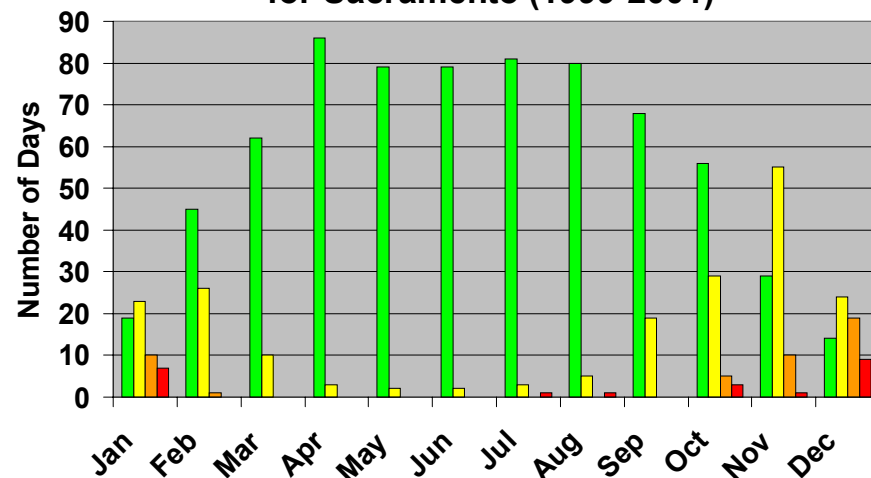
- Monthly frequency
- Day-of-week frequency
- Holiday frequency

Conceptual Model – Climatology (2 of 2)

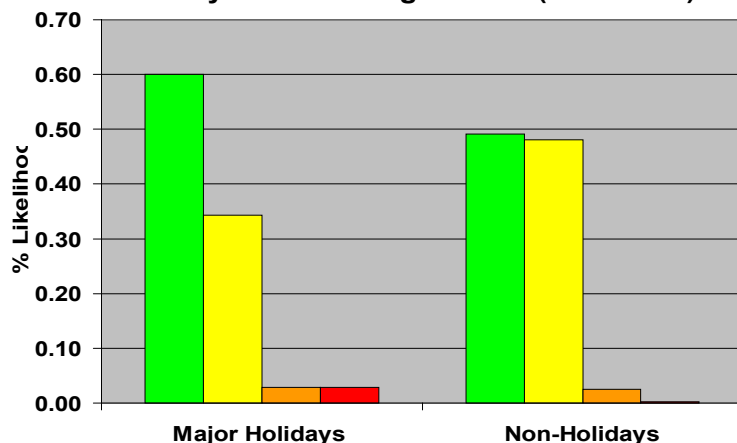
AQI Category (Based on PM2.5) by Month for Washington D.C. (1999-2001)



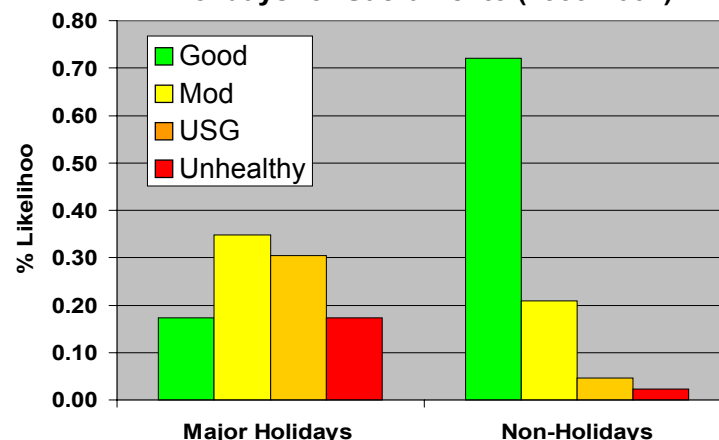
AQI Category (Based on PM2.5) by Month for Sacramento (1999-2001)



AQI Category for Major Holidays and Non-Holidays for Washington D.C. (1999-2001)



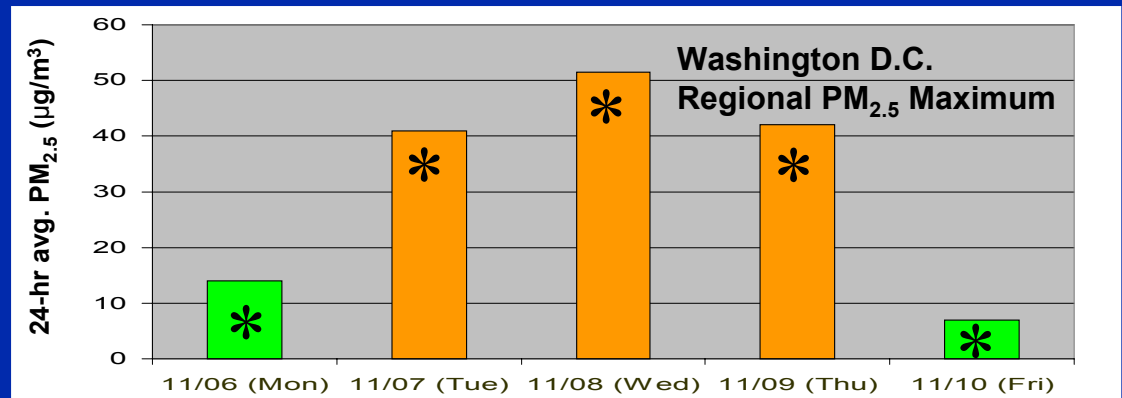
AQI Category for Major Holidays and Non-Holidays for Sacramento (1999-2001)



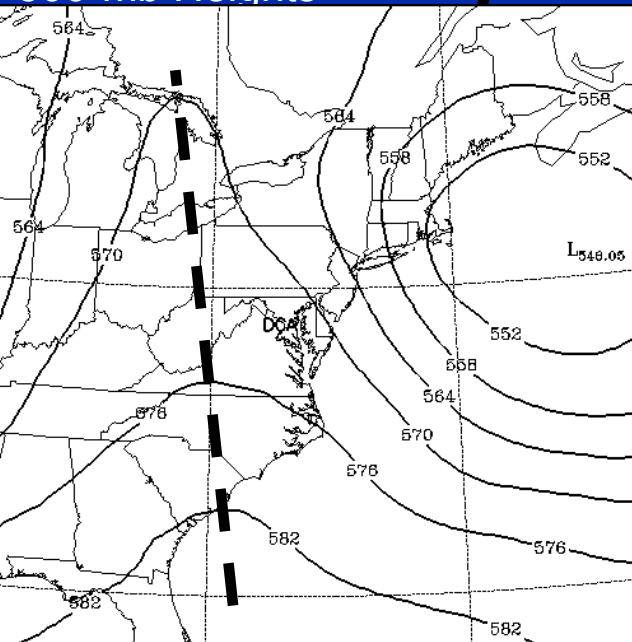
Conceptual Model – Weather Characterization

- Common large-scale weather features associated with high $PM_{2.5}$
 - Aloft ridge of high pressure or approaching trough
 - Prefrontal conditions
 - Temperature inversion and stable conditions
 - Local stagnation or transport between cities (East)
 - Holiday effect
- Small-scale subtle features are important and are becoming evident in daily forecasting

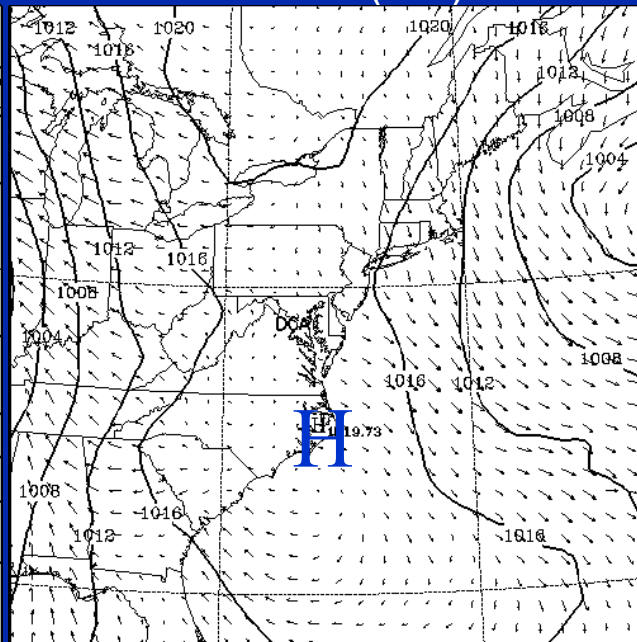
Conceptual Model – Case Studies



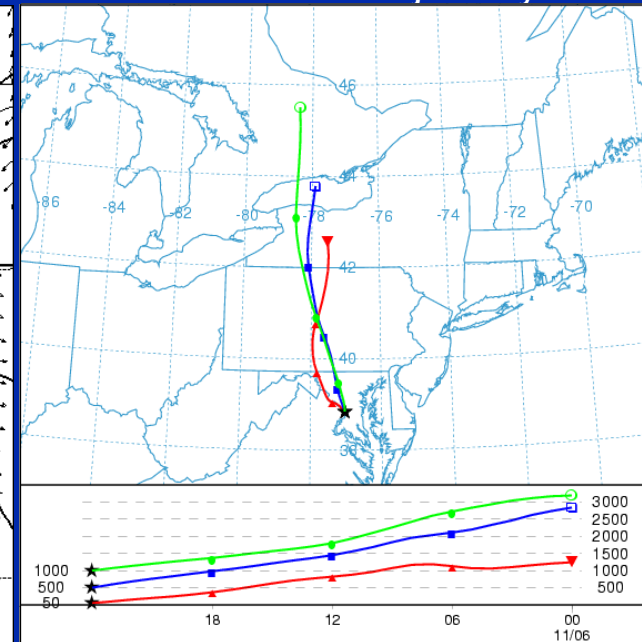
500-mb Heights



Surface Pressure (msl)



36-hr Backward Trajectory



Forecasting Tool Development (1 of 2)

Phenomenological Tables

Winter Guidelines:	Washington D.C. Predicted 24-hour Average PM _{2.5} Concentration Range			
	0-15 µg/m ³	16-40 µg/m ³	41-65 µg/m ³	66-150 µg/m ³
	Good	Moderate	USG	Unhealthy
Upper-air Pattern (40%)	A strong trough with an axis east of Washington D.C.	Any of the Following: A broad ridge A shortwave ridge Zonal Flow A weak short wave trough A cut-off trough over the southeast	A well-defined ridge over the Mid-Atlantic region; the axis may have passed to the east of Washington D.C.	In the 1999-2001 data set no Unhealthy days occur during the winter.
Inversion Strength and Duration (30%)	No inversion present below 850 mb	Weak to moderate inversion below 850 mb that may break	Strong surface inversion that does not break throughout the day.	
Surface Wind Strength (20%)	*Strong surface wind (>10 kts)	Light to Moderate (0-10 kts) from any direction. Northeasterly direction enhances transport	Light (0-4 kts) in the D.C. area or Moderate winds (4-10 kts) out of the Northeast	
Other (10%)	* + Large amounts of precipitation; rain is more effective at removing PM than snow Or * + A well-defined surface cold front has passed through the area within the past 24 hours Or * 500-mb pattern is zonal or moderate ridging, light surface winds, and a previous day AQI value between 0 and 30	This AQI category occurs on close to half of the days.	This AQI category is unlikely to occur. It only happened on 12 days in the last three winters.	
Previous Day AQI category	Any Category	Any Category	Any Category	

* Indicates that the meteorological criterion does not have to exist in order for category to be fulfilled.
+ When these atmospheric conditions occur they are likely to overwhelm other criterion

Forecasting Tool Development (2 of 2)

Statistical tools

- Regression and CART
- Initial assessment is more difficult than for ozone
 - Rare event forecasting
 - Multiple pathways to form PM
 - High emissions variability
 - Limited historical data
- Use some stability and transport parameters

Washington D.C.
PM_{2.5} Winter Climatology

AQI	% of days
Unhealthy	0
Unhealthy for SG	2
Moderate	42
Good	56

Operational Forecasting

Sample Daily E-mail

NOTE: These forecasts are not being sent to the public and are only intended for internal use by your agency during this pilot PM2.5 forecasting project.

Regional PM2.5 Forecast for Baltimore

Today's forecast - Monday, January 27: Good (32 AQI)

Tomorrow's forecast - Tuesday, January 28: Moderate (52 AQI)

Yesterday's observed maximum - Sunday, January 26: Moderate (60 AQI)

Discussion:

A strong trough of low pressure aloft moved through the area late yesterday, resulting in strong vertical mixing and lower PM2.5 concentrations. Surface high pressure is building into the area today, but moderate northerly winds will keep PM2.5 levels Good. Tomorrow, there will be zonal flow aloft, and the surface high pressure system will be centered right over the Baltimore area, resulting in light winds. These conditions will allow PM2.5 levels to reach the low end of Moderate.

This forecast was issued on Monday, January 27, 2003 at 12:36:37 PM PST

Forecaster:

Dianne Miller

Sonoma Technology, Inc.

office: 707-665-9900

cell phone: 707-338-0304

dianne@sonomatech.com

Initial Forecasting Results

Forecasting since January 2 for 10 cities

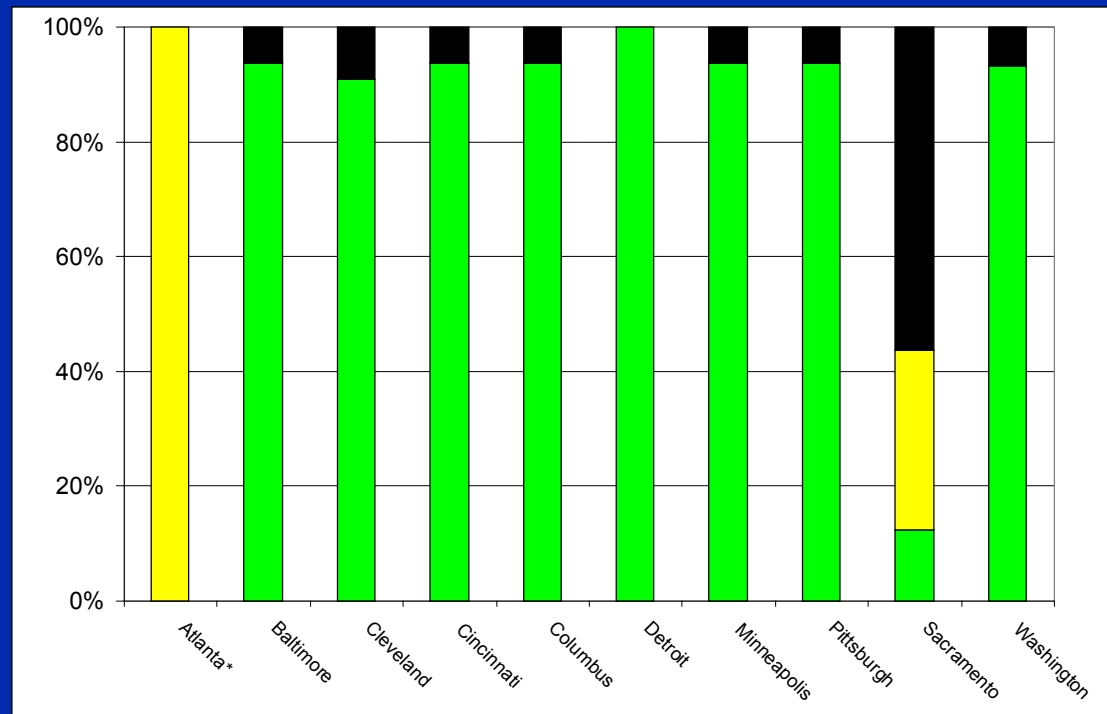
- Using phenomenological tables (modifying as we gain more experience)
- Weather conditions have generally not been conducive to high PM_{2.5} except in the West

Next-day Forecasts

■ Hit - Good

■ Hit - Moderate and above

■ Miss



Forecasting Software – Overview

Centralized, web-based approach to forecasting

- Ingests, processes, stores, and integrates large amounts of information
 - Weather observations and forecasts
 - Air quality observations and forecasts
 - Air quality links
 - Verification statistics
 - Climatologies
- Customizable by forecasters in each agency
- Expandable to other cities, pollutants, and forecast tools

Forecasting Software – Example

City Forecast

Region: Date: Aug 04, 2002

City:

Pollutant: Units: Concentration

($\mu\text{g}/\text{m}^3$)	Today	Day 1	Day 2	Day 3	Day 4
Regression	35	50	35	50	35
Box Model	40	60	40	60	40
CART	40	40	40	40	40
Conceptual	50	60	50	60	50
Consensus	40	50	40	50	40

Links

NWS Discussion	NWS Discussion	NWS Discussion
Weather Charts	Weather Charts	Weather Charts
Satellite	Satellite	Satellite
Radar	Radar	Radar

Regional Forecast Discussion for Midwest on Aug 04, 2002

PM 2.5 Forecast Discussion for Columbus, OH on Aug 04, 2002

Forecaster writes city discussion here or can view past discussions

Yesterday	Today	Day 1	Day 2	Day 3	Day 4
50	60	50	60	50	50

($\mu\text{g}/\text{m}^3$)

Spell Check Save Print Send Modify Send

Login

User Name:

Password:

Login

Verification Sites

Screenshots from Forecaster Software

Time Series

Region: Date: Aug 04, 2002

City:

☐ Date Selected

☐ Prior Day

☐ Prior 7 Days

☐ Between Aug 04, 2002 and Aug 24, 2002

☒ Today vs Yesterday

Template: PM vs 850 T

Create Edit Delete

RH (percent) T (degrees.)

0 50 100 0 20

01/21/00 01/23/00 01/25/00

Date/Time

Print Export as GIF

Next Steps

- Start the process for the remaining 11 cities
 - Conceptual model development
 - Tool development
 - Daily forecasting
- Document the results
- Conduct regional workshops to transfer knowledge and products to the 21 cities

Contacts

- U.S. EPA

- Pat Dolwick, (919) 541-5346, dolwick.pat@epa.gov
- John White, (919) 541-2306, white.johne@epa.gov

- Sonoma Technology, Inc.

- Tim Dye, (707) 665-9900, tim@sonomatech.com
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